(12) UK Patent Application (19) GB (11) 2 295 008 (13) A

(43) Date of A Publication 15.05.1996

(21) Application No 9522164.4

(22) Date of Filing 30.10.1995

(30) Priority Data
(31) 4440494 (32) 12.11.1994 (33) DE

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(51) INT CL^6
F23D 14/22 14/18 , F24H 1/22

(52) UK CL (Edition O)
F4T TGBX T174
U1S S1976

(56) Documents Cited
US 4421476 A US 4230443 A

(58) Field of Search
UK CL (Edition N) F4A ADD , F4T TC TEH TEJ TGBX TGDX TGD1 TGX
INT CL^6 F23D 14/18 14/20 14/22 14/24 , F24C 3/04 , F24H 1/22 1/38 1/40
Online:w.p.i.

(54) Water heater with catalytic gas burner

(57) In a water heater with a catalytic gas burner which has at least two catalysts (12, 14, 16) arranged in series, in each of which part of the total amount of fuel supplied is reacted and to each of which is assigned a heat exchanger (38, 40) which cools the emerging gas mixture, it is proposed to feed the fuel to the individual catalysts (12, 14, 16) in separate partial quantities, with the result that the fuel reacts completely in all the catalyst stages and no undefined combustion products are formed.

FIG. 1

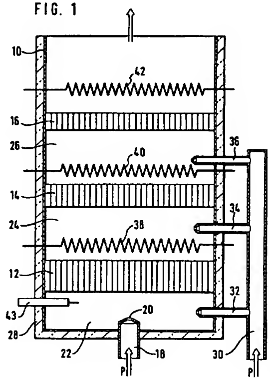

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FIG. 1

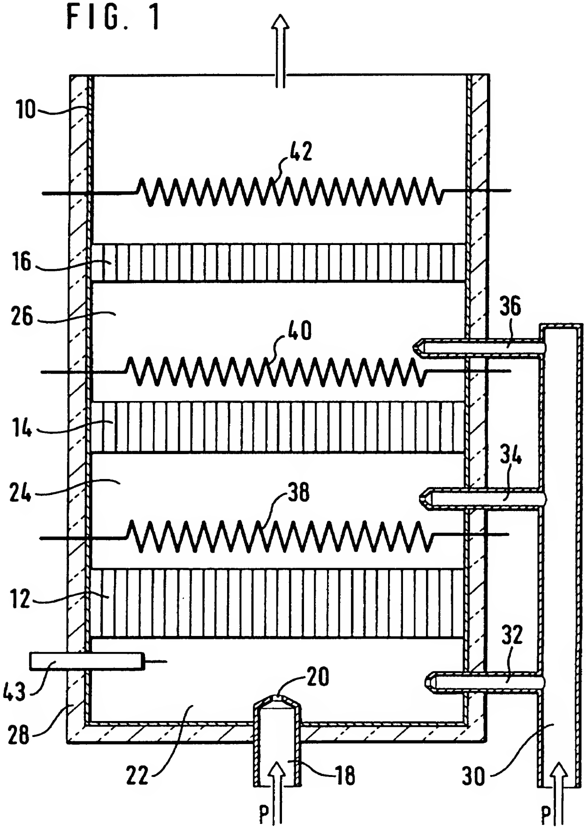


FIG. 2

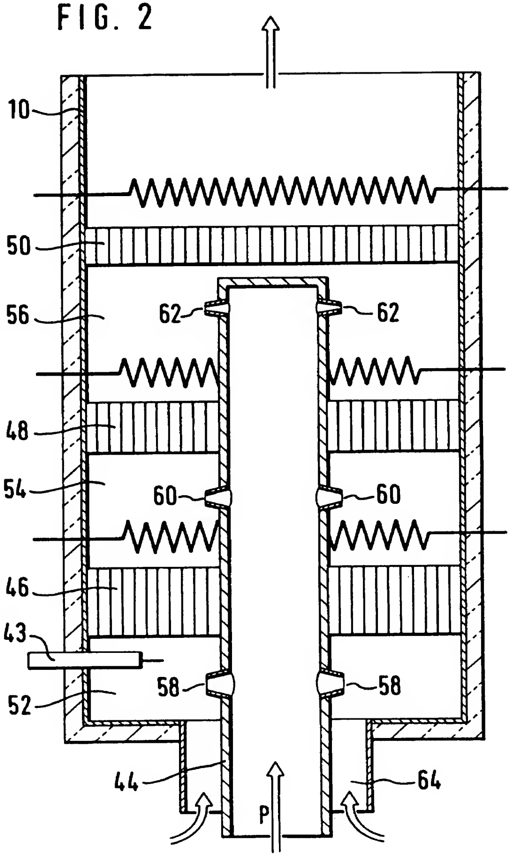
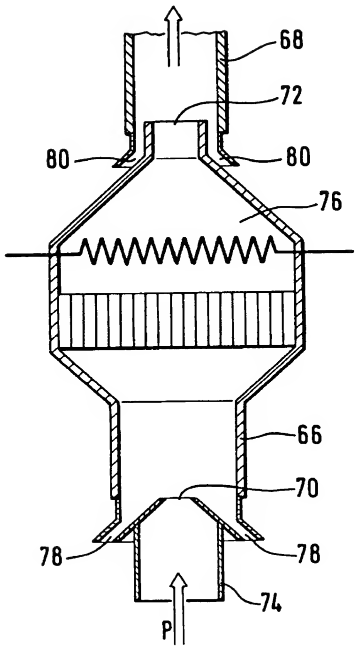


FIG. 3



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Water heater with a catalytic gas burner

Prior art

The invention takes as its starting point a water heater of the generic type of the main claims. In burners with at least two catalysts, the fuel is reacted in stages and the gas mixture is intercooled after each stage, giving a favourable ratio of burner output to combustion or exhaust-gas temperature. In a known embodiment of a water heater of the type stated at the outset (DE 33 32 572 A1), the entire quantity of fuel provided for combustion is supplied to the inlet of the first, upstream catalyst, whereas the combustion air required is fed to the individual catalysts in partial quantities. As a result, incomplete combustion takes place in the first catalyst, and this can lead to soiling of the catalyst and of adjacent functional elements and to cooling problems if the advantage of exhaust-gas temperature limitation achieved by means of reaction in stages is to be maintained.

Advantages of the invention

In contrast, the arrangement according to the invention with the characterizing features of the main claim has the advantage that clean combustion of the partial quantity of fuel supplied takes place even in the first catalyst and that no undefined combustion products are formed there. Supply of the fuel in partial quantities allows good control of the burner within the

limits determined by the gas pressure. The control concept should include the cooling of the mixture flows emerging from the catalysts to the temperature desired for mixture with the partial quantities of fuel supplied. By constructing the outlet openings for the fuel as metering nozzles, the partial quantities and their ratios with respect to one another are dependent only on the gas pressure once the nozzle diameter has been fixed.

The subclaims relate to advantageous further developments and refinements of the arrangement according to the main claim.

In a preferred embodiment, the entire quantity of combustion air required for complete reaction of the fuel in all the catalysts is introduced into a mixing chamber arranged ahead of the first catalyst. The excess of air thereby made available cools the first catalyst, thus preventing the reaction temperatures from rising to a temperature range detrimental in terms of NO_x formation and, above all, of the operating behaviour and life of the catalyst.

The air/exhaust gas mixture flowing out of the first catalyst is subsequently cooled to an extent such that the reaction temperatures do not reach the detrimental temperature range in the second catalyst either. The process is the same in all the catalysts which may follow.

An embodiment which is advantageous in terms of the design possibilities for the catalysts and of the assembly and cleaning of the burner is obtained if the fuel is introduced into mixing chambers ahead of the catalysts via a conduit system attached externally to the burner casing.

A compact embodiment of the burner is obtained if the fuel is supplied via a fuel pipe which passes centrally through the catalysts and is provided with wall openings in the region of mixing chambers arranged ahead of the catalysts.

The cooling of the air/exhaust gas mixture by the water to be heated can be accomplished by means of a

combustion chamber wall which is cooled in the appropriate areas. In this case, heat transfer can be improved by the constructional measure of providing a correspondingly small annular gap through which the gas mixture is guided along the casing wall of the burner. A more simple configuration of the burner casing is possible if the heat exchangers are arranged in the mixing chambers of the catalysts.

To start the burner, the proposal is to provide an ignition device in a mixing chamber arranged ahead of the first catalyst. Ignition preferably takes place at a heavily cut-back burner output. The hot exhaust gases which are formed bring the catalysts up to operating temperature. After the flame has been extinguished by briefly interrupting the fuel supply, the fuel/air mixture is blown into the heated catalyst and reacted. If the ignition device is arranged downstream of the first catalyst and preferably upstream of the introduction of the fuel for the second catalyst, the first catalyst has heated up after a short time to an extent such that the fuel/air mixture reacts within the catalyst. After this, the flame goes out by itself and the burner thus continues operating in a purely catalytic manner.

One alternative comprises a metallic design for the first catalyst and, if required, all the catalysts. The catalysts can then be brought up to operating temperature by electric heating and the ignition device is dispensed with.

As a further development of the invention, it is proposed to draw in the partial quantities of fuel metered to the individual catalysts in mixing pipes arranged ahead of the catalysts by means of a jet pump effect by the combustion air flowing in via nozzles or by the inflowing gas mixture. In this embodiment, the ratio of the quantity of fuel drawn in to the combustion air flowing through or to the gas mixture flowing through is determined solely by the ratio of the respective diameters of the nozzles and the mixing pipes and is independent of the burner output set.

A further alternative for implementing the inventive idea stated in the main claim comprises also supplying the quantity of combustion air required for complete reaction of the fuel to the individual catalysts in partial quantities.

Instead of a separate catalyst and heat exchanger in each case, it is possible to provide a sub-assembly which combines both functional elements in each catalyst stage. This can be a catalytically coated metallic or ceramic heat exchanger. Water or even the combustion air can be used as the cooling medium. Different modes of construction are possible for such heat exchangers, e.g. finned-tube heat exchangers, coiled-tube heat exchangers, shell and tube heat exchangers or plate-type heat exchangers. By combining the catalyst and the heat exchanger in this way to form a common sub-assembly or functional unit, it is possible to simplify the construction of the burner and achieve a significant reduction in the burner volume required.

Drawing

Three exemplary embodiments of the invention are depicted in the drawing and explained in greater detail in the following description. Figures 1 to 3 each show, schematically, one of the exemplary embodiments in longitudinal and partial section.

Description of the exemplary embodiments

The water heater shown in Figure 1 has a cylindrical burner casing 10, in which a first catalyst 12 and two further, differently dimensioned catalysts 14 and 16 are arranged in series at an axial distance from one another. Leading into the burner casing 10 is a feed line 18 for the combustion air, its outlet 20 lying in a mixing chamber 22 arranged upstream of the first catalyst 12. A mixing chamber 24 is formed upstream of the second catalyst 14 and a mixing chamber 26 is formed upstream of

the third catalyst 16. The burner casing 10, which is open at the downstream end, is surrounded at the circumference and at the upstream end by an insulating layer 28.

Fixed to the outside of the burner casing 10 is a fuel line 30, from which individual branch lines 32, 34, 36 lead radially into the mixing chambers 22, 24, 26 and there open into differently dimensioned nozzle openings. Arranged in the mixing chambers 22, 24, 26 are heat exchangers 38, 40, 42 which form part of a conduit system (not shown specifically in the drawing) which carries the water to be heated. An ignition device 44 for starting the burner is provided in mixing chamber 22.

During the operation of the burner, the entire quantity of air required for combustion is injected into the mixing chamber 22 of the first catalyst 12. At the same time, a quantity of fuel is blown into the mixing chamber 22 via branch line 32 and, in the case of complete reaction in the catalyst 12, this quantity of fuel heats the air/fuel mixture to the maximum permissible temperature in the catalyst. After flowing through the catalyst 12, the gas mixture is cooled by heat exchanger 38, whereupon further fuel is added via branch line 34. Heat exchanger 38 is dimensioned in such a way that the mixing temperature of the gas mixture and the additional fuel supplied which results ahead of the second catalyst 14 is not below the lowest temperature that can still be permitted for the reaction in catalyst 14.

The quantity of fuel blown into mixing chamber 24 is such that, in the process of its complete conversion in catalyst 14, the maximum permissible temperature of the latter is not exceeded. In the case of both catalysts 14 and 16, the following processes take place as described in conjunction with the first catalyst stage. After the complete reaction of the overall amount of fuel supplied, the residual heat is removed from the exhaust gas by heat exchanger 42. Given a certain burner output, the size and number of catalysts is obtained from the permissible difference between the inlet and working

temperature of the catalysts. This, in turn, depends on the optimum operating temperature and on the most favourable temperature in terms of service life. Instead of introducing the fuel into the individual catalyst stages on one side, introduction can also take place in a rotationally symmetrical manner via, in each case, a plurality of branch lines opening into a mixing chamber, whereby better mixing of air or gas mixture and fuel is achieved.

The exemplary embodiment shown in Figure 2 is a variant of the embodiment shown in Figure 1, in this variant the fuel being supplied under pressure through a central fuel pipe 44 which passes centrally through catalysts 46, 48, 50. The fuel pipe 44 is in each case provided in the region of mixing chambers 52, 54, 56 with a ring of wall openings 58, 60, 62 of nozzle-like design, the effective cross-section of which is matched to the partial quantity of fuel metered to each catalyst stage. The central air supply takes place via an annular passage 64 which surrounds the fuel pipe 44 and opens into the mixing chamber 52 of the first catalyst stage.

In the exemplary embodiment shown in Figure 3, the fuel is drawn into the individual catalyst stages by the combustion air supplied under pressure. For this purpose, each catalyst stage is provided with a mixing pipe 66, 68, in the inlet region of which the outlet opening 70, 72 of a central air supply pipe 74 and of a mixing space 76 provided on the outlet side of the catalyst stage, is arranged, the said outlet openings being constricted in the form of a nozzle. The outlet openings 70, 72 are surrounded by fuel passages 78, 80 or by an enveloping central gas supply pipe, these likewise opening into the mixing pipes 66, 68. By a jet pump effect, the air or gas mixture draws the fuel into the mixing pipe 66 and 68, the ratio of air to fuel or gas mixture to fuel being largely independent of the burner output set.

Claims

1. Water heater with a catalytic gas burner which has a first catalyst and at least one second catalyst, arranged downstream in the flow path of the combustion gases, in each of which part of the total amount of fuel supplied is reacted and to each of which is assigned a heat exchanger through which the water to be heated flows and which cools the emerging gas mixture, characterized in that the fuel is supplied to the individual catalysts (12, 14, 16 and 46, 48, 50 respectively) in separate partial quantities.

2. Water heater according to Claim 1, characterized in that the entire quantity of combustion air required for complete reaction of the fuel in all the catalysts (12, 14, 16) and (46, 48, 50) respectively is introduced into a mixing chamber (22 and 52 respectively) arranged ahead of the first catalyst (12 and 46 respectively).

3. Water heater according to Claim 1 or 2, characterized in that the fuel is introduced into mixing chambers (22, 24, 26) ahead of the catalysts (12, 14, 16) via a conduit system (30, 32, 34, 36) attached externally to the burner casing (10).

4. Water heater according to Claim 1 or 2, characterized in that the fuel is supplied via a fuel pipe (44) which passes centrally through the catalysts (46, 48, 50) and is provided with wall openings (58, 60, 62) in the region of mixing chambers (52, 54, 56) arranged ahead of the catalysts (46, 48, 50).

5. Water heater according to Claims 1 and 4, characterized in that the entire quantity of combustion air supplied passes through an annular passage (64)

surrounding the fuel pipe (44) into the mixing chamber (52) of the first catalyst (46).

6. Water heater according to one of the preceding claims, characterized in that the heat exchangers (38, 40) are arranged in the mixing chambers (24, 26) of the catalysts (14, 16).

7. Water heater according to one of the preceding claims, characterized in that an ignition device (43) for starting the burner is provided in a mixing chamber (22, 24 and 52, 54 respectively) adjacent to the first catalyst (12 and 46 respectively).

8. Water heater according to one of the preceding claims, characterized in that the catalysts are of metallic design.

9. Water heater according to Claim 1, characterized in that the partial quantities of the fuel metered to the individual catalysts are drawn into mixing pipes (66, 68) arranged ahead of the catalysts by means of a jet pump effect by the combustion air or gas mixture flowing in via nozzles (70, 72).

10. A water heater substantially as herein described with reference to Figure 1, Figure 2 or Figure 3 of the accompanying drawings.

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Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report)	Application number GB 9522164.4
Relevant Technical Fields (i) UK Cl (Ed.N) F4T (TEH, TEJ, TGBX, TGDI, TGX, TC, TGDX) F4A (ADD) (ii) Int Cl (Ed.6) F23D 14/20, 14/22, 14/24, 14/18; F24C 3/04; F24H 1/22, 1/38, 1/40	Search Examiner R F PHAROAH Date of completion of Search 21 DECEMBER 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE: WPI	Documents considered relevant following a search in respect of Claims :- 1-10

Categories of documents

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&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
A	US 4421476 A (GULDEN)	
A	US 4230443 A (GULDEN)	

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